

Establishing Econometric Modeling Equations for Lumpy Skin Disease Outbreaks in the Nile Delta of Egypt under Current Climate Conditions

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Abstract—This paper aimed to establish econometrical equation models for the Nile delta region in Egypt, which will represent a basement for future predictions of Lumpy skin disease outbreaks and its pathway in relation to climate change. Data of lumpy skin disease (LSD) outbreaks were collected from the cattle farms located in the provinces representing the Nile delta region during 1 January, 2015 to December, 2015. The obtained results indicated that there was a significant association between the degree of the LSD outbreaks and the investigated climate factors (temperature, wind speed, and humidity) and the outbreaks peaked during the months of June, July, and August and gradually decreased to the lowest rate in January, February, and December. The model obtained depicted that the increment of these climate factors were associated with evidently increment on LSD outbreaks on the Nile Delta of Egypt. The model validation process was done by the root mean square error (RMSE) and means bias (MB) which compared the number of LSD outbreaks expected with the number of observed outbreaks and estimated the confidence level of the model. The value of RMSE was 1.38% and MB was 99.50% confirming that this established model described the current association between the LSD outbreaks and the change on climate factors and also can be used as a base for predicting the of LSD outbreaks depending on the climatic change on the future.

Keywords—LSD, climate factors, econometric models, Nile Delta.

I. INTRODUCTION

LSD is an infectious disease infecting the livestock and characterized by lesions on the skin and other parts of the body. LSD was distributed in some regions of African countries. It has been diagnosed in several regions of the Middle East and in 2013 it was established in Turkey [10].

Earlier studies [5] reported that cold weather may adversely affect insect vector and infected saliva probably contribute the spread of LSD. A study conducted in Ethiopia by [4] revealed that LSD occurred from July to November and extends to December where the high moisture was recorded. In addition, [2] reported that the warm and humid climate has been considered as enrichment media for the propagation of the biting flies in charge of LSD transmission than cool temperature.

Few studies focused on the relationship between the climate factors and their influence on the extent of LSD outbreak especially in Egypt, our research focused on establishing

regional models for exploring the role of the climatic variables such as temperature, relative humidity, and wind speed with LSD outbreaks in the Nile delta of Egypt.

II. MATERIAL AND METHODS

A. Study Area

This study was conducted in the Nile Delta region (Fig. 1). Nile Delta is the delta formed in Northern Egypt (Lower Egypt) where the Nile is divided into two sections pouring into the Mediterranean Sea. Damietta branch is in the east and ends in Damietta and Rosetta Branch is in the west and ends at the city of Rosetta. It is one of the largest deltas in the world - stretching from Port Said in the east to Alexandria in the West and was named the Delta for it resembles a triangle. It occupies an area of 240 kilometers on the Mediterranean coast. The length of the Delta from north to south about 160 km. Delta starts from the south, near the city of Cairo when Barrages charity. The Nile delta region comprised of ten governorates and constitutes about 85% of cattle production in Egypt [6].

B. Data Source and Preparation

1. LSD Data

Data of LSD outbreaks on cattle farms were obtained from the database of the World Animal Health Information Database (WAHID) (OIE: animal health Egypt) and Ministry of Agriculture and Land Reclamation of Egypt during 1 January, 2015 to 30 December, 2015. During this period, the numbers of outbreaks were collected and summarized, and then the average numbers of outbreaks of LSD for each month all over the period are calculated.

2. Meteorology Data

Data of climate conditions were taken from the report of the weather underground of Egypt website database. The average monthly data were calculated for the study period. Data included temperature (C0), relative humidity (%) and wind speed (Km/h) and the average values were calculated per month from January 2015 till the end of December 2015 [6]. Summary of the mean of the outbreaks and average values of metrological data were presented in Table I.

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TABLE I
SUMMARY OF THE MEAN VALUES OF OUTBREAKS AND THE CLIMATE
FACTORS

Months	Mean Outbreaks (No)	Mean values of climate factors		
		Temp (C ^o)	Wind (km/h)	RH (%)
January	3.11	19.52	10.53	58.82
February	3.87	21.50	12.13	61.20
March	6.17	22.31	12.43	59.37
April	6.71	21.23	11.16	60.12
May	21.50	27.41	12.96	69.12
June	18.97	29.55	13.69	70.30
July	24.88	31.72	13.58	72.47
August	20.62	31.17	13.46	72.99
September	5.52	25.69	9.83	63.68
October	8.228	23.63	9.22	60.50
November	4.93	20.64	8.52	59.22
December	3.10	18.44	9.28	60.63

C. Establishing the Models

Regression analysis was performed for establishing the model. This model incorporated the average number of LSD outbreaks and meteorological data. A correlation analysis was firstly applied to investigate the degree of relationship between the outbreaks and other climate variables. The regression analysis (multiple, forward, stepwise, backward and block) was done to determine the best regression equation, which represents the risk degree of climate factors on incidence of LSD outbreaks.

The empirical model was generated based on the multiple regression model defined as:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_i X_i$$

where Y is the number of disease outbreaks, β_0 is the constant and fix it to equal zero value, X_1, \dots, X_i are the key environmental factors, and β_1, \dots, β_i are their regression coefficients.

D. Validation of the Model

The expected number of outbreaks were calculated, and then compared with the values that actually observed. There are two statistical methods are used for determining the accuracy and efficiency of the constructed empirical model, which are the root mean square error (RMSE) and mean bias (MB) [3]. Root mean square error (RMSE) measure the differences between the values of outbreaks predicted by the model and the values of outbreaks actually observed. The more approach of root mean square error to zero the higher the accuracy of model.

On the opposite side, the mean bias (MB) is utilized to assess the model execution, which speaks to the level of correspondence between the mean expectation and the mean perception. Bring down numbers are ideal and values under Zero show under expectation.

The conditions for RMSE, MB and its rates are given;

$$RMSE = \left(\sum_{i=1}^n \frac{(xp - xo)^2}{n} \right)^{0.5}$$

$$RMSE\% = \left(\frac{RMSE}{x} \right) \times 100$$

$$MB = \sum_{i=1}^n xp - \frac{x_o}{n}$$

$$MB\% = \left(\frac{MB}{x_o} \right) \times 100$$

where n= number of observations, xp = predicted values, xo= observed values, \bar{x}_o = the average of observed values.

III. RESULTS

According to the data presented in Table I, it has been noticed that the number of outbreaks of LSD peaked during the months of May, June, July, and August and gradually decreased to reach the lowest level during the months of January, February, and December.

Table II presented the correlation between the outbreaks of LSD and the metrological data. Data indicated a positive correlation was found between the LSD outbreaks and temperature ($r = 0.78$; $P < 0.01$). In addition, a positive correlation was recorded between the LSD outbreaks and both of the wind speed and relative humidity. The correlation coefficient of the LSD outbreaks and the wind speed was ($r = 0.87$; $P < 0.01$) and the coefficient with relative humidity was ($r = 0.67$; $P < 0.05$).

In regard to the multiple regression analysis (Table III), it has been investigated that temperature increased by one degree caused increased on the number of LSD outbreaks by 0.75 times. Moreover, increasing of the wind speed by one kilometer per hour caused increased on the outbreaks by 1.57 times and also increasing of the relative humidity by 1% led to increase on the outbreaks by 1.62 times. Referring to the coefficient of determination (adjusted R²); the value of the coefficient was 0.92 meaning that the change in the response variable (the number of outbreaks) was referred to the changes on the predictors (temperature, wind speed, and relative humidity) by 92%.

With reference to RSM and MO, the calculated RSM was 1.38 and Mo was 0.5 demonstrating that the difference between the values of LSD outbreaks expected by this equation and the values of outbreaks principally observed was 1.38% and the confidence level for this model was 99.50%.

TABLE II
CORRELATION BETWEEN THE OUTBREAKS AND THE CLIMATE FACTORS

	Outbreak	Temp	Wind	RH
Outbreak	1			
Temp	0.78**	1		
Wind	0.87**	0.45	1	
RH	0.67*	0.56*	0.61*	1

* Significant at $P < 0.05$ ** Significant at $P < 0.01$

IV. DISCUSSION

The importance of studying LSD reflected to its danger during the period of study in Egypt. Nile Delta constitutes 85% of cattle production that is the reason for exploring the

danger of LSD in this triangular area of Egypt. Previous studies conducted by [5] reported that cold weather may adversely affect insect vector and infected saliva probably contribute the spread of LSD. In an agreement with our findings, [4] revealed that LSD outbreaks were higher in July.

However, [2] reported that the warm and humid climate has been considered as favorable media for the propagation of the biting flies in charge of LSD transmission than cool temperature.

TABLE III
MULTIPLE REGRESSION ANALYSIS BETWEEN THE OUTBREAKS AND THE CLIMATE FACTORS

	Multiple R	R-square	Adjusted R-Square	St Err of Estimate	Confidence Interval 95%	
Constant	0.904	0.913	0.921	1.02	Lower	Upper
	Coefficient	Standard Error	t-Value	p-Value		
	0	NA	NA	NA	NA	NA
Temp.	0.75	0.31	10.34	0.001	0.48	1.02
Wind	1.57	0.52	15.91	0.001	1.03	2.11
RH	1.62	0.39	19.25	0.01	1.10	2.13

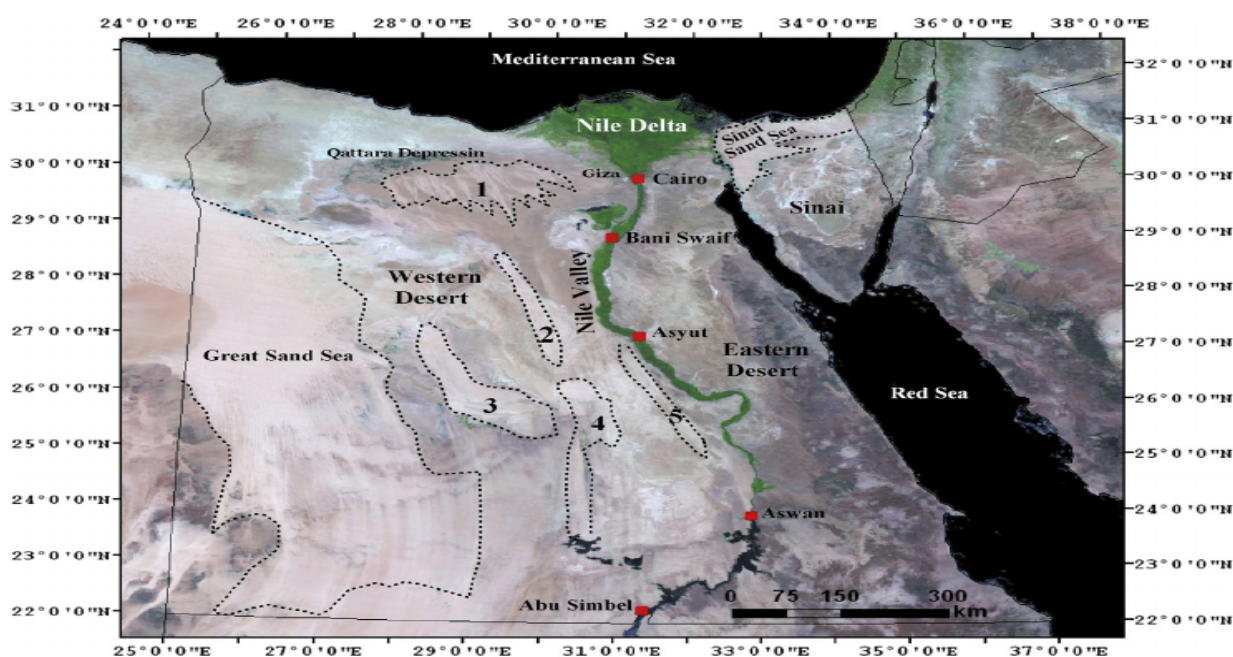


Fig. 1 Topographic distribution of the Nile delta of Egypt

In regard to our established model in this study, there are might be rare studies investigated the modeling linked between the climate factors and the outbreaks of LSD and especially in Egypt. Recent spatio-temporal study conducted by [1] concluded that the most imperative natural indicators that added to the biological specialty of LSDV included yearly precipitation, arrive cover, mean diurnal range, kind of animals generation framework, and worldwide domesticated animals densities. In addition, [8] described the potential role of the climate for the changes in spatial and temporal distribution of some diseases sensitive to moisture and found that LSD one of the important diseases affected. Furthermore, [7] indicated that environmental change influences the occurrence of domesticated animals maladies transmitted by direct contact because of changes in the recurrence and span of creature contacts.

ACKNOWLEDGMENTS

The author would like to thank the people in the Ministry of Agriculture and Land Reclamation of Egypt who provided the required data.

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